

Description

TECHNICAL FIELD

[0001] The present invention relates to a fluid pump, which is suitable for use in pumping fuel in an internal combustion engine, and particularly a compression ignition internal combustion engine.

BACKGROUND OF THE INVENTION

[0002] A fuel circuit feeding a vehicle engine comprises a lift or low pressure fuel pump that flows fuel from a low pressure tank to a high pressure fuel pump that pressurizes fuel to a high level prior to its delivery to injectors of the engine.

[0003] A high pressure pump known in the art includes a rotating camshaft which cooperates with a plunger, or a plurality of plungers, to pressurize fuel in a compression chamber. Each plunger is slidable within a bore defined within a housing, with the compression chamber defined at the end of the bore so that movement of the plunger within the bore reduces and expands the volume of the compression chamber during a pumping cycle as the camshaft rotates. The camshaft is guided in rotation between two bushings. In operation, a back flow of low pressure fuel fills the volume surrounding the camshaft and flows through the bushings, lubricating the surfaces, and returning to a low pressure fuel return line as well as to a low pressure inlet and the cam box. Hydraulic waves propagate in the back flow and generate pressure pulsations and noise within the pump assembly. The pressure pulsations impact the other components of the low pressure fuel return line, such as a filter, and are undesirable.

[0004] Solutions have been proposed to address the problem of pressure pulsations in the back flow of fuel, including the use of low pressure regulators that feed the pulsations back to the back flow. However the use of low pressure regulators has disadvantages, in particular because of the impact on CO₂ emissions. Another approach is to arrange inlet orifices in the low pressure return line but, as they restrict the flow cross section, the low pressure pump of the fuel circuit is then required to provide additional flow to compensate the restriction.

[0005] In our previous co-pending patent application, PCT/EP2014/076371 (unpublished), a solution is proposed to include an integral fluid damper in the camshaft so as to damp pressure waves propagating in the fluid lubricating the camshaft.

[0006] It is an object of the invention to propose an alternative solution to the aforementioned problem.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an object of the present invention to address the above mentioned problems by providing a fluid pump, such as a fuel pump, comprising a

housing within which is received, between rotational guiding means, a camshaft cooperating with a pumping plunger. The camshaft is arranged to rotate and actuates the pumping plunger to reciprocally move to pressurize fuel within a pump chamber. The camshaft is provided with an integral fluid damper comprising a bellows device so that hydraulic waves propagating in a fluid lubricating the camshaft and flowing through the rotational guiding means are damped by the bellows device.

[0008] The fluid pump is typically a fuel pump of the type used in a compression ignition internal combustion engine, or a pump for another type of fuel.

[0009] The fluid which lubricates the camshaft and the rotational guiding means may be the same fluid that is pressurized by the pump (for example fuel), but need not be the same. For example, a lubricant such as oil may lubricate the camshaft, whilst the pump delivers pressurized fuel.

[0010] The fluid which lubricates the camshaft and the rotational guiding means is typically derived from a flow of fuel in a low pressure circuit of the pump. Typically, the low pressure circuit includes a low pressure return line, a low pressure inlet flow to the pump, which derives from the low pressure return line, and the cam box which houses the cam shaft.

[0011] The deformation of the bellows device (also referred to as 'bellows'), in use, by the propagation of pressure waves within the low pressure circuit enables hydraulic pressure pulses to be absorbed. The provision of the integral damper incorporating a bellows device is a solution to the problem of hydraulic pressure pulses that provides advantages as it can be manufactured with minimum effort and a low number of parts and, hence, cost.

[0012] The hollow part of the camshaft may be open at one end to communicate with fluid in the low pressure circuit downstream of the rotational guiding means.

[0013] In another embodiment, the hollow part of the camshaft may be closed at one end so that there is no communication between the hollow part and fluid in the low pressure circuit downstream of the rotational guiding means.

[0014] The bellows device may be fixed at or near one end to the camshaft, for example with one or more weld points. The means of fixing (e.g. weld points) may be the means by which the hollow part is closed to communication with the fluid in the low pressure circuit downstream of the rotational guiding means.

[0015] In another embodiment, the hollow part of the camshaft may be open at one end to communicate with fluid in the low pressure circuit downstream of the rotational guiding means (e.g. by having a reduced number of weld points). In other words, the fixing means may be configured to close communication between the hollow part and the fluid in the low pressure circuit downstream of the rotational guiding means.

[0016] The bellows device may, in one embodiment, take the form of bellows which are filled with a gas to enhance damping of the pressure pulsations in the fluid.

The gas may be pressurized or unpressurised. In other embodiments, the bellows device need not be gas-filled.

[0017] Typically, the rotational bushings take the form of coaxial bushings (i.e. first and second bushings) which are spaced apart along the camshaft with the camshaft extending therethrough.

[0018] The camshaft is partially hollow to define a blind bore within which the bellows device is arranged. The blind end of the bore may communicate with a channel extending through the wall of the camshaft so as to establish a fluid communication between the external surface of the camshaft and the bore in the camshaft. The channel may communicate with the low pressure circuit e.g. in the region of the low pressure inlet to the pump.

[0019] In contrast to the known low pressure regulator solution, if there is no flow between the inlet to the damper and the low pressure circuit, there is an advantage because there is no impact on CO₂ emissions due to wasted energy.

[0020] In one embodiment, the camshaft is a composite shaft comprising a cylindrical axle shaft over which a cam form is press fitted, for example. The camshaft may conveniently take the form of a relatively cheap component, such as a steel tube, onto which the cam form is fixed and into which the bellows device may be fixed.

[0021] In another aspect the invention resides in a camshaft for a fluid pump of the aforementioned type having a blind bore formed therein and comprising a bellows device located within the blind bore to damp pressure waves propagating within the low pressure circuit. The fluid pump is typically a fuel pump for use in an engine such as a compression ignition internal combustion engine.

[0022] Within the scope of this application it is expressly envisaged that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment or aspect can be combined in any way and/or combination, unless such features are incompatible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The present invention is now described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of a fuel circuit in a vehicle;

Figure 2 is a cross section of a fluid pump according to a first embodiment of the invention; and

Figure 3 is a cross section of a fluid pump according to another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] In the following description, similar elements will be designated with the same reference numbers. Also, to ease and clarify the description the orientation of the figures will be referred to without any limiting intention. Therefore, words and expressions such as "left or right, and front and back" may be utilized without intending to impart any limitation.

[0025] Figure 1 is a representation of a vehicle 8 including an engine 10 having fuel equipment 12. This is not limited to any specific type of vehicle, or of fuel, and the teachings of the invention are applicable to diesel as well as to gasoline or any other fuel, and indeed to any type of fluid pump.

[0026] In the rear of the vehicle 8 are arranged a fuel tank 14 and a low pressure pump 16 and, in the front, on the vehicle engine 10, are arranged a high pressure pump 18, a manifold 20, also known as a common-rail, distributing high pressure fuel from the high pressure pump 16 to a plurality of injectors 22. These components are arranged in fluid communication with each other via a low pressure fuel supply line 24 extending from the tank 14 to the high pressure pump 18, a high pressure circuit 26 confined between the high pressure pump 18, the manifold 20 and the injectors 22 and, a low pressure circuit including a fuel return line 28 extending from the front to the rear of the vehicle 8 to flow some fuel back from the injectors 22 to the tank 14.

[0027] Numerous variants of fuel equipment 12 exist with vehicles 8 having the engine in the front or in the rear and the fuel tank arranged at the other end. It is usual for both the low pressure supply and return fuel lines 24, 28 are relatively long and extend between the front and the rear of the vehicle 1. Together, these fuel lines 24, 28 form the low pressure circuit for the pump, which also includes the cam box within which the camshaft is housed. Within the low pressure circuit, low pressure fuel flows and hydraulic waves or pressure waves propagate. For example, the hydraulic waves are generated by the operation of the high pressure pump or by an injection event.

[0028] A first embodiment of the invention is now described in reference to Figure 2 which shows the drive part of the high pressure fuel pump 18. The pump 18 comprises a fixed housing comprising a left (front) part 32 spaced apart from a right (rear) part 34. The front and rear housing parts 32, 34 may be part of one and the same housing, spaced by a bore 35 provided between them, or the parts 32, 34 may be separate housing parts with a space 35 in between. A camshaft 36 extends through the parts 32, 34 and is arranged for rotation within the housing 32, 34. The camshaft 36 extends along a first longitudinal axis A1 and cooperates with a pumping plunger or piston (not shown) via a cam 40 and a cam follower (also not shown). In the embodiment in Figure 2, the camshaft 36 has one cam form 40 arranged between the housing parts 32, 34.

[0029] To enable rotation of the camshaft 36 within the housing, each housing part 32, 34 is provided with a respective front or rear bushing 38a, 38b. The bushings 38a, 38b are coaxially arranged with the longitudinal axis A1 of the camshaft 36.

[0030] As the camshaft 36 rotates, in use, the cam 40 drives the cam follower which cooperates with the pumping plunger (or a tappet coupled thereto), to cause the plunger to reciprocate within a plunger bore, aligned along a second axis, A2. Reciprocal motion of the plunger within the plunger bore causes fuel within a high pressure pump chamber at the end of the plunger bore to be pressurised. Multiple plungers may be driven by the same camshaft 36 depending on the configuration of the fuel pump.

[0031] As indicated by the arrows in Figure 2, a flow of fuel F taken from the low pressure return fuel line is delivered along an inlet path to provide an inlet flow to lubricate the bushings 38a, 38b and the camshaft 36. The fuel flow F divides into a front back flow FF and a rear back flow FR. Each of the back flows FF and FR passes through its respective bushing 38a, 38b and lubricates the rotating surfaces of the bushing 38a, 38b and the camshaft 36. The front back flow FF collects in an annulus just forward of the front bushing 38a, and exits to the tank 14 via a drilling 39 provided in the front housing part 32. The rear back flow FR flows between the camshaft 36 and the rear bushing 38b and flows through a rear chamber 41 located adjacent to the rear of the rear housing part 34 before exiting to the tank 14. Hydraulic waves propagate in the back flows FR, FF generating undesired pulsations in the low pressure circuit (comprising the return flow lines FR, FF, the inlet flow to the pump and the cam box), and it is an object of the invention to reduce the impact of such pulsations.

[0032] There are various reasons for pressure oscillations in the low pressure circuit. The main reason is the movement of the camshaft 36 with the associated movement of fluid. This fluid under motion leads to various reflections and wherever the free flow is hindered by geometrical obstacles, pressure spikes appear and are immediately transmitted throughout the low pressure circuit. To overcome these undesirable effects, the camshaft 36 is provided with a fluid damper comprising a bellows device 42 in the form of bellows mounted within a blind bore 44 provided in the camshaft 36. The camshaft 36 is thus partially hollow to define the blind bore 44, with the bore 44 extending axially inside the camshaft 36 along the axis A1 from a point approximately at the middle of the camshaft 36 to the right (rear) extremity of the camshaft 36 where it opens into the rear back flow FR. The blind end of the bore 44 is located between the front and rear bushings 38a, 38b.

[0033] The blind bore 44 is in fluid communication with the interior of the pump 10 via a channel 46 which extends from the blind bore 44, in the vicinity of the blind end, to the outer surface of the camshaft 36 in the space 35 between the housing parts 32, 34. The bellows 42 are

mounted within the bore 44 with a first end thereof located at the rear of the bore 44, adjacent to the rear back flow FR. The first end of the bellows 42 is fixed within the blind bore 44, to the rear end of the camshaft 36, via a fixing means in the form of a plurality of welds 50 which close communication between the bore 44 and the rear back flow FR. The bellows 42 take the form of an expandable and contractible vessel with concertinaed sides which flatten out in the absence of a pressure pulse to elongate the vessel, and collapse back to adopt a shorter, wider state when a pressure pulse is applied. The bellows 42 are filled with a gas to provide a means for damping pressure waves propagating in fluid within the bore 44 as the bellows 42 are compressed against the gas, in use. The bellows 42 may be filled with pressurised gas, or unpressurised gas, depending on the extent of expected pressure pulsations and, hence, the extent of damping required. In other embodiments the bellows 42 need not be filled with a gas at all.

[0034] In operation, the inlet flow F from the low pressure fuel return line 28 fills the inside of the bore 44 via the channel 46. The hydraulic waves propagating along the inlet flow F therefore enter the channel 46, and compress the bellows 42 so that the waves are damped before they propagate further through the bushings 38a, 38b to form the back flows, FF and FR.

[0035] In another embodiment, as shown in Figure 3, the bellows 42 are fixed at or near the end of the blind bore 44 by a reduced number of weld points 50 (two in the illustration shown) so that communication between the end of the bore 44 and the rear back flow FR of the low pressure circuit is maintained.

[0036] Reference in this specification to bellows or a bellows device shall be taken to mean any expansible and contractible vessel, the volume of which can be changed by compression or expansion, by means of a force due to applied pressure, so as to absorb pressure pulses. A bellows device typically has concertinaed sides, as shown in the illustrations in Figures 2 and 3, to allow it to contract/collapse in length. However, other embodiments are envisaged which would also provide a bellows-type function. For example, in another embodiment the bellows device is provided by a plurality of conical washers arranged in a stack and compressible to reduce the length of the stack to absorb the pressure pulses. It is also envisaged that the bellows device may take the form of a single compressible element, which expands and contracts to change its volume by displacing a fluid or gas through an outlet so as to absorb the pressure pulses.

[0037] The camshaft 36 in embodiments of the invention may be a mono-bloc construction, made of one piece with the integral cam form 40, or can be composite, made of a cylindrical axle cam shaft over which is fixedly arranged a cam form. An advantage of the latter construction is that a lower grade steel may be used for the camshaft (e.g. a steel tube) than that which is used for the cam.

[0038] It will be appreciated by a person skilled in the art that the invention could be modified to take many alternative forms to that described herein, without departing from the scope of the appended claims.

Claims

1. A fluid pump (18) comprising a housing (30) receiving a camshaft (36) which is rotatable within rotational guiding means (38a, 38b), the camshaft cooperating with a pumping plunger of the fluid pump to actuate the pumping plunger to reciprocally move in order to pressurize fluid within a pump chamber, the camshaft (36) being exposed to a fluid to lubricate the camshaft, in use, **characterized in that** the camshaft (36) is provided with an integral fluid damper (42) comprising a bellows device (42) configured to damp hydraulic waves propagating in the fluid lubricating the camshaft (36) and flowing through the rotational guiding means (38a, 38b). 5
2. The fluid pump (18) as claimed in claim 1, wherein the camshaft (36) is partially hollow (44), and wherein the bellows device (42) is arranged inside the hollow part (44). 10
3. The fluid pump (18) as claimed in claim 2, wherein the camshaft (36) is further provided with a channel (46) extending through the wall of the camshaft (36) establishing a fluid communication between the external surface of the camshaft (36) and the hollow part (44). 15
4. The fluid pump (18) as claimed in claim 2 or claim 3, wherein the hollow part of the camshaft (36) is a blind bore (44). 20
5. The fluid pump (18) as claimed in any of claims 2 to 4, wherein the hollow part (44) receives fuel from a low pressure circuit of the pump. 25
6. The fluid pump (18) as claimed in any of claims 2 to 5, wherein the hollow part (44) of the camshaft (36) is open at one end to communicate with fluid in the low pressure circuit downstream of the rotational guiding means (38a, 38b). 30
7. The fluid pump (18) as claimed in any of claims 2 to 5, wherein the hollow part (44) of the camshaft (36) is closed at one end so that there is no communication between the hollow part (44) and fluid in the low pressure circuit downstream of the rotational guiding means (38a, 38b). 35
8. The fluid pump (18) as claimed in any of claims 1 to 7, comprising a fixing means for fixing the bellows device (42) to the camshaft (36) at or near one end of the camshaft (36). 40
9. The fluid pump as claimed in claim 8, wherein the fixing means (50) comprises one or more welds (50). 45
10. The fluid pump (18) as claimed in claim 8 or claim 9 when dependent on claim 7, wherein the fixing means is configured to close communication between the hollow part (44) and fluid in the low pressure circuit downstream of the rotational guiding means (38a, 38b). 50
11. The fluid pump (18) as claimed in any of claims 1 to 10, wherein the bellows device (42) includes bellows filled with a gas. 55
12. The fluid pump (18) as claimed in claim 11, wherein the gas is pressurized.
13. The fluid pump (18) as claimed in claim 11, wherein the gas is unpressurized.
14. The fluid pump (18) as claimed in any of claims 1 to 13, wherein the camshaft (36) is a composite shaft comprising a cylindrical axle shaft to which a cam is fitted.
15. The fluid pump (18) as claimed in claim 14, wherein the cam (40) is press fitted onto the composite shaft.

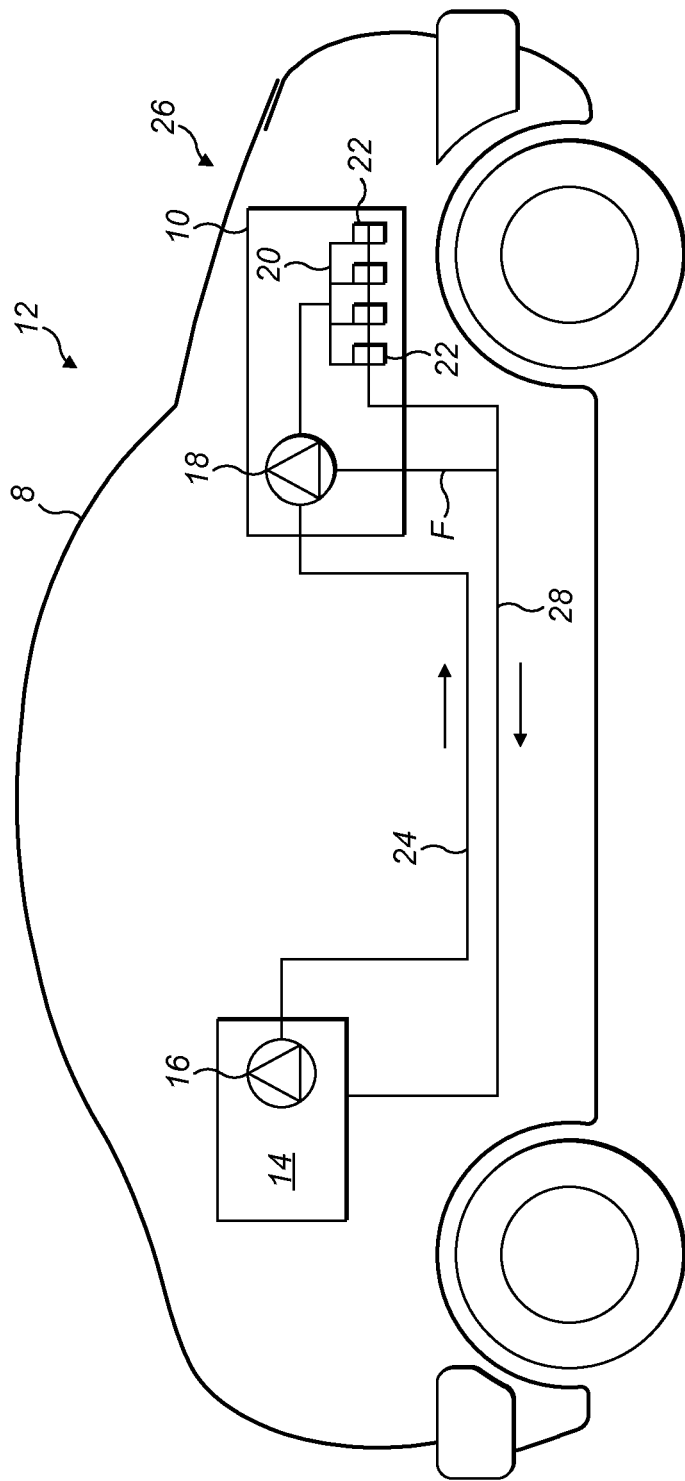
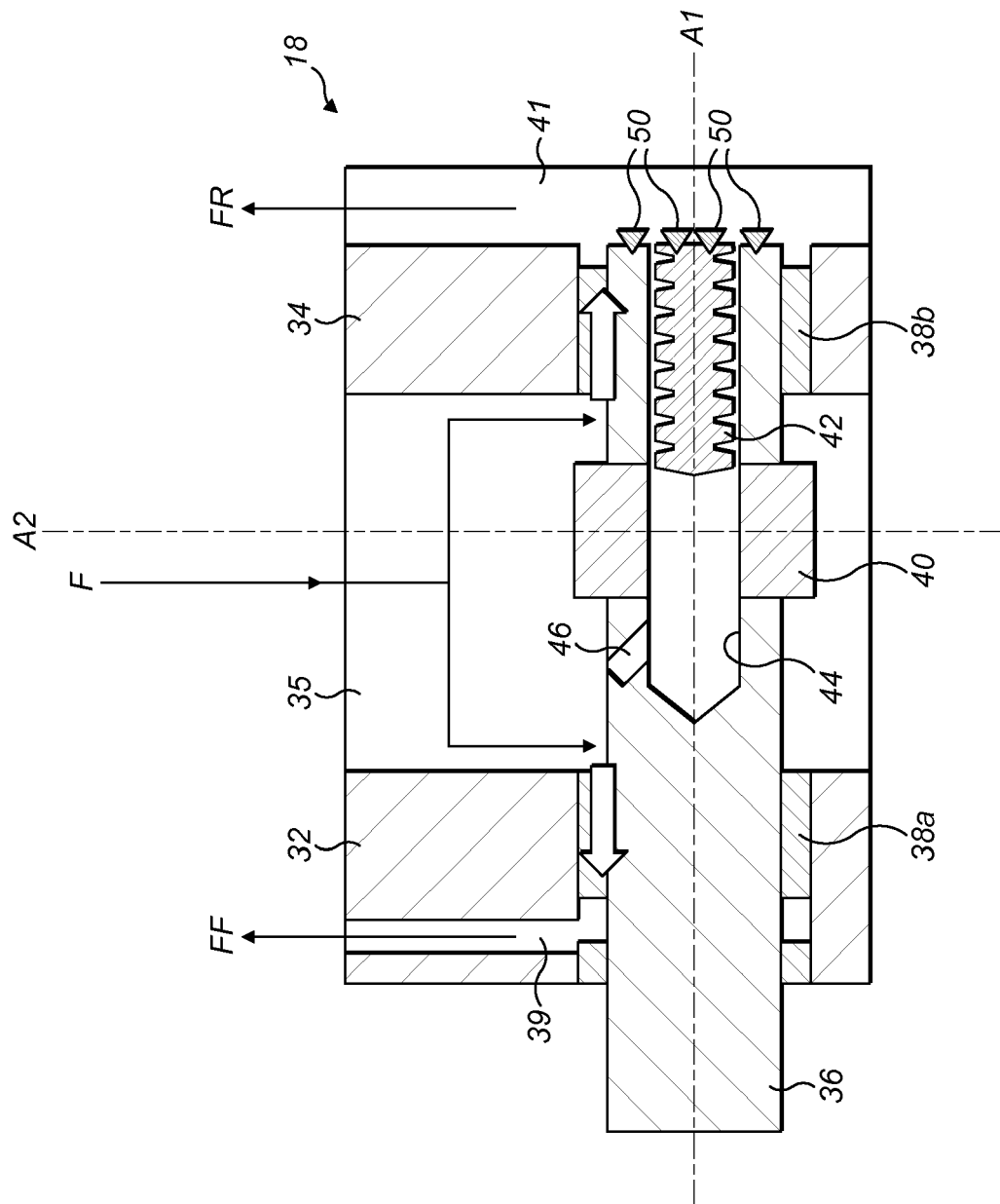


FIG. 1



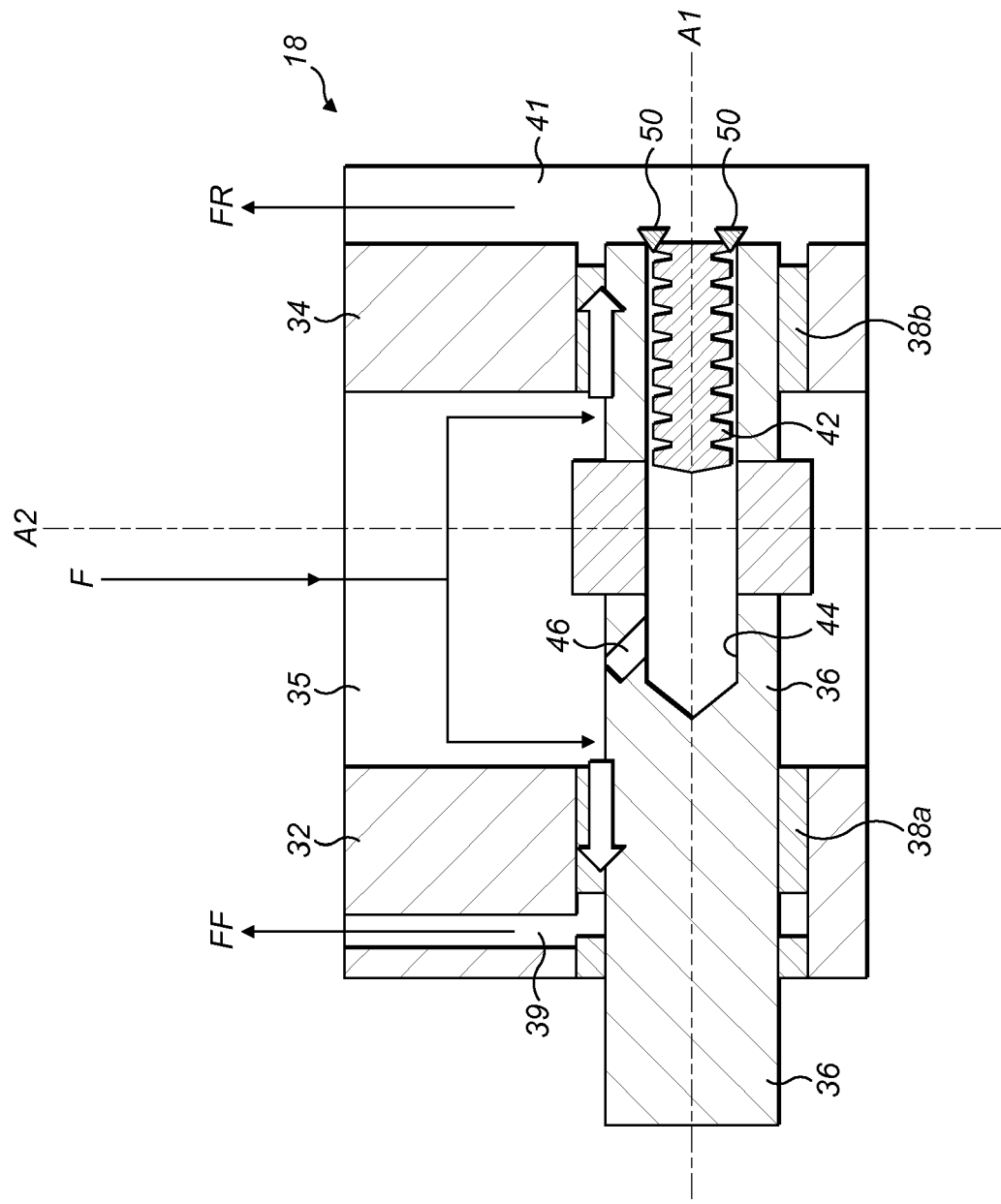


FIG. 3



EUROPEAN SEARCH REPORT

Application Number
EP 16 17 5584

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	GB 2 309 270 A (UNISIA JECS CORP [JP]) 23 July 1997 (1997-07-23) * page 12, lines 5-28 * * page 8, line 29 - page 10, line 2; figures 1-3 *	1,8,9, 14,15 2-7, 10-13	INV. F02M63/00 F02M55/04 F02M59/10 F02M59/44 F02M59/48
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			TECHNICAL FIELDS SEARCHED (IPC)
			F02M
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 12 September 2016	Examiner Boye, Michael
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 16 17 5584

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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12-09-2016

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REFERENCES CITED IN THE DESCRIPTION

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